Title: “Be fruitful and multiply” a Developmental Theology of Creation

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Abstract

Most of the contemporary discussions pertaining to Biblical accounts of creation have focussed on topics related to Darwinian evolution. These discussions, based on listening to the viewpoints of evolutionary biologists, have helped to transform how we understand natural theology. However, what is missing from these discussions is what modern developmental biology has to say about creation. Developmental biology *is* the study of creation. The paucity of theological discussions on development is surprising given that the Bible contains hundreds of verses that either directly or indirectly refer to plant and animal development. What I am suggesting is that a contemporary understanding of creation can benefit from a knowledge of modern developmental biology.

Biblical

By including insights from developmental biology into theological thinking, we gain a more profound understanding of what is meant by ‘God’s creation’. Throughout this essay I will refer to ‘developmental theology,’ defined as a creation theology informed by insights from modern developmental biology. The verse “Be fruitful and multiply”(Gen 1.28) is one of many possible starting points for discussions on developmental theology[1]. This verse equally applies to all creatures, not only humans. Plants and animals are ever fecund and self-renewing. For example, trillions of embryos arise moment by moment over vast periods of time spanning billions of years. This creative explosion in embryonic life is especially evident in northern regions, when after quiescent winter we experience developmental biology's equivalent of the Big Bang when life is again renewed in all its glory. Endless developmental events abound in springtime including when the sap within trees begins to flow once again to produce leaves that harvest solar energy, when seeds warm up and develop into a vast variety of plants, when flowers bloom and when animals produce countless embryos. 'Flowers appear on the earth; the season of singing has come' (Song of Songs 2.12). Based on observing developmental events in Nature, the springtime renewal has long been associated with the Easter event, the resurrection of new life that is mediated by developmental processes and ordained by God having the birth, death and resurrection of our Lord Jesus Christ at the centre of this annual creative event.

For the injunction "Be fruitful and multiply" to manifest in the world, a vast array of developmental processes were created and these processes continue to evolve. Therefore, having both the 'eye of faith and science', as Ted Peters once remarked in one of his essays[2], the study of developmental biology is a wonderful way to appreciate the gift of God's creation. This is how I have personally understood developmental biology for the past six decades. The more I understand development, the more I understand the nature of God's creation. By studying development, one directly peers through a divine window and sees how God continually creates creatures. This peering into God's creative acts takes place in the present moment, not in the remote past, and is an activity that anyone can easily study, both in high-tech laboratories and in our gardens. Not only are developmental biologists studying how God makes embryos in the present moment, but the study of developmental processes also provides us with a means of peering into the essence of Darwinian evolution. Why, because biologists now understand that development is the key towards understanding evolution. Most developmental biologists these days (including myself) keep one eye on the embryo and the other on evolution and by doing so think about ontogenetic creaturely development in terms of evolution. This relatively new approach is sometimes referred to as evolutionary developmental biology or 'evo-devo'. But I prefer 'developmental evolution' because by placing 'development' before 'evolution' this helps to emphasize the role of the embryo in evolution. Whereas it has long been appreciated that ontogeny and phylogeny are intimately associated with each other, it was just a few decades ago when developmental biologists realized that studying only flies and mice will not tell us how creaturely diversity arose, a shift in thinking that threw open the door to study the development of all creatures[3].

Development is not only intimately connected with evolution, but it is also one with ecology[4]. Developmental ecology is a vibrant field of study and is another source of information for theologians writing about ecology. This holistic, integrative approach is sometimes called evolutionary-developmental-ecology or 'evo-devo-eco.' Note that the word 'development' is situated between 'evolution' and 'ecology'. This word order is highly significant because development links together both evolution and ecology. Furthermore, the use of this triune language is significant because biologists now realize that the role of natural selection is to modify embryonic processes that generate phenotypic diversity. And so, we have the use of triadic language by modern biologists that reminds Christians of the Trinity. Therefore, if pondered on the semiotic level, this shared triune language holds a special place both for both theologians and modern developmental biologists. One of the most profound expressions of triune language in theology is found in the writings of St. Bonaventure. Fundamental to Bonaventure's theology is his concept of 'emmanation-exemplarity-consummation'[5] For Bonaventure, Jesus Christ is the 'Exemplar' linking together as one God the Father and the Holy Spirit in the profound language of the Trinity. More will said about Bonaventure's theology and his 'principle of fecundity' later in this essay, but for now we can see on how the modern biologist's view development, as that which binds together evolution and ecology as a unified whole, reminds those of us studying biology with a mind of faith how in Christ Jesus all things are held together (Col. 1.17).

Meditations on creaturely development are as old as humanity itself, therefore it comes as no surprise that ancient forms of meditations on creaturely development are found throughout the Bible. What is surprising is that theologians who are interested in exploring the interface of God and biology have largely ignored modern developmental biology in their discussions of Darwinian evolution. What I am suggesting in this essay is that developmental biology is a crucial epistemological layer in understanding both Darwinian evolution and God's creation. The concept of 'layers of knowledge' is a central concept in T.F.Torrance's theology and is helpful in understanding the relationship of developmental biology to 'developmental theology'[6]. For Torrance, beginning with our personal and experiential knowledge of Jesus Christ, our thoughts gradually move towards the most subtle aspects of theology, the Trinity, as we grasp more fully the reality of Jesus Christ in our lives. In this model, there is first the tacit level of theology in which one intuitively grasps the reality of God and His relationship to creation, in the next layer one develops a theology to explain our experience and in the most subtle layer of knowledge we develop a refined understanding of God's eternal being, all the while grounded in our personal relationship with Jesus Christ[7]. With this model in mind, God's self-revelation as revealed by the Bible and indirectly in Nature can perhaps be understood as being the most profound and subtle layer of developmental biology. At the surface level, we research and ponder the empirical basis of development and then gradually our minds guided by faith move into deeper levels of thought and finally arrive at the theological basis of development, God the Creator. This journey of the mind takes us from grossest layer of knowledge (developmental anatomy, physiology etc), then to a more subtle epistemological layer that involves understanding developmental signal transduction pathways (how trillions of cells are continually communicating with each other moment by moment) to an even more subtle level, developmental genetics, next moving into a knowledge of quantum level interactions between molecules responsible for making creatures, and then our thoughts transcend reflections on gross matter (Bonaventure's 'vestige'[8]) and finally merge with God the Father, Son and Holy Spirit in the divine ultimate oneness of reality.

Having introduced the idea of developmental theology, let us survey some of the key passages in the Bible that directly or indirectly draw our attention to developmental biology: 'The Word became flesh'(Jn 1.14); 'For you created my inmost being; you knit me together in my mother's womb. My frame was not hidden from you when I was made in the secret place, when I was woven together in the depths of earth'(Ps. 139.13-15); 'I praise you because I am fearfully and wonderfully made'(Ps. 139.14); 'I made you grow like a plant of the field. You grew and developed and entered puberty' (Ezekiel 16.7); 'Then the Lord God formed a man from the dust of the ground and breathed into his nostrils the breath of life, and the man became a living being' (Gen. 2.7); 'The Lord God made all kinds of trees grow out of the ground' (Gen. 2.9); 'Now the Lord God had formed out of the ground all the wild animals and all the birds of the sky' (Gen. 2.19); Ps 33.15: 'he who forms the hearts of all' (Ps. 33.15); 'for he knows how we are formed, he remembers that we are dust' (Ps.103.14); 'I was formed long ages ago, at the very beginning, when the world came to be. When there were no watery depths, I was given birth, when there were no springs overflowing with water' (Proverbs 8.23-24); 'As you do not know the path of the wind, or how the body is formed in the mother's womb, so you cannot understand the works of God, the maker of all things' (Eccl. 11.5); 'everyone who is called by my name, whom I created for my glory, whom I formed and made' (Isa. 43.7); 'This is what the Lord God says- he who made you, who formed you in the womb, and who will help you' (Isa.44.2);'This is what the Lord says- your Redeemer, who formed you in the womb: I am the Lord, the Maker of all things, who stretches out the heavens, and who spreads out the earth my myself' (Isa. 44.24); 'Before I formed you in the womb I knew you' (Jer.1.5); 'so in Christ we, though many, form one body, and each member belongs to all the others' (Rom. 12.5); 'My dear children, for whom I am again in the pains of childbirth until Christ is formed in you' (Gal. 4.19); 'For in Christ all the fullness of the Deity lives in bodily form' (Col. 2.9) and 'By faith we understand that the universe was formed at God's command, so that what is seen was not made out of what was visible' (Heb. 11.3). In addition to these verses, there are sixty-four references to 'womb', one hundred references to 'seed', the nativity stories of Jesus and the account of John the Baptist as a fetus leaping about within the womb of Elizabeth. All of these passages directly or indirectly refer to development. Therefore, the Biblical creation narratives not only present a cosmic view of creation, but also a pre-scientific narrative on ontogenetic development.

Any scientific theology must be explicit about methodology, as emphasized by T.F. Torrance and A.E. McGrath[9]. There are two excellent books that discuss methods used to investigate 'divine development': Scott Gilbert's *Developmental Biology*[10] and Sean Carroll's *From DNA to Diversity*[11]. What one discovers after having read these books is that changes in embryonic developmental programs underlie Darwinian evolution. God's glorious creatures arose by means of changes to developmental programs and these modifications form the biological basis of 'continuous creation' or 'creatio continua'[12].

Continuous creation is studied at various levels by developmental biologists, from the level of embryonic morphogenesis to the genetic level. As a reminder, genes made of DNA that produce ‘offspring’ called RNA by means of transcription. Essentially, transcription can be understood as a form of divine communication at the material level, or as Bonaventure said, communication at the level of ‘vestige’. Genes, like creatures, are inherently reproductive and expressive in their nature. This inspired biologist Richard Dawkins, a devout atheist, to write a controversial book entitled “The Selfish Gene” a highly reductionist concept that has been critically reviewed by Alister McGrath and Mary Midgley[13]. Over time single genes replicate themselves to form gene families. Some gene families are very large. For example, the human FGF (fibroblast growth factor) family has 23 members[14]. In plant development there are over 450 members belonging to the pentatricopeptide (PRP) gene family.[15] And so, “Be fruitful and multiply” applies not only to creatures but also to genes. The function of gene replication is to expand developmental communication. Genetic communication, referred to by biologists as ‘signal transduction’, is how cells are constantly in dialog with each other. Signal transduction is required for both embryogenesis and good health. When cell signaling is disrupted, a common outcome is cancer, which is an escalating global pandemic in which it is expected there will be 29.4 million new cases per year and 16 million deaths per year by 2040.[16] When carcinogens (many of which are produced by human activities) cause adult cells to revert back to having an embryonic-like gene expression, we call this ‘cancer.’ [17] St. Bonaventure wrote extensively on the most subtle aspect of expressionism. Here is what David Luy said about Bonaventure's 'expressionism': "At the base of Bonaventure's semiotics are his expressionism and exemplarism. The entire world is best understood as God's own language."[18] God's expressionism extends to the level of gene expression and can therefore be envisaged as God's language at work within embryos.

How is expressionism studied in embryos? The most widely used method to explore spatio-temporal expressionism in embryos is called *in situ* hybridization. This method allows one to directly visualise when and where genes are expressed in embryos. Another method that maps proteins in time and space is immunocytochemistry. Both these methods are discussed in detail by Gilbert and Carroll, as previously cited[19] . In situ hybridization maps the expression of RNA in embryos, whereas in immunocytochemistry labelled antibodies bind to embryonic proteins. The interaction between antibody and embryonic protein is a highly relational three-dimensional event that occurs at the atomic level. The divine 3D shape and charge of every protein is mediated by a class of proteins called 'molecular chaperones'. Research shows that HSP90 (heat shock protein having a molecular mass of 90,000 Daltons) is important in evolution based on mutation analysis and drug interference experiments that alter with the wildtype HSP90 function in embryos[20]. Reflections on the highly relational interaction of proteins at the ‘vestige’ level of creation can function to move one’s mind to ponder more subtle thoughts concerning relational interactions, ultimately drawing the mind like a bee towards nectar towards the relational theology of the glorious Trinity[21]. And so, an understanding of molecular interactions in light of Bonaventure's theology can take us back to sublime thoughts of the Trinity, when both the eye of faith and the eye of science are wide open. Mulling all of this over ‘under God’ as Torrence once said[22], we can obtain a theological appreciation of developmental evolution. Given that development is highly relational in nature, one only needs to take a small step to see how development can be viewed in terms of relational theology. Subtly existing alongside the chain of relational events responsible for the production of embryonic complexity are signs of the economic Trinity. All of the highly relational interactions occurring within embryos can be envisaged to point to God, using the language of semiotics, and can perhaps be interpreted as signs of God’s immanence and help us, as Bonaventure said, find our way from ‘vestige’ back to God.[23]

Let us now take a closer look at two examples from modern developmental biology that underlie the theological concept of continuous creation. The first example is limb development and the second is anterior-posterior axis development because both of these examples reveal the hidden simplicity that underlies the complexity of creaturely morphology. In 1997, developmental biologists Neil

Shubin, Clifford Tabin and Sean Carroll published an important paper entitled "Fossils, Genes and the Evolution of Animal Limbs" in which they discuss how limb development in arthropods (for example, fruit flies) and vertebrates (including humans) share the *same* underlying genetic regulatory system[24]. This was surprising because chordates (the phylum that includes vertebrates) diverged from arthropods at the gross anatomical level during the Cambrian era more than 540 million years ago. And so, whereas the anatomy of the animal limb is highly divergent at the morphological level, paradoxically at the developmental genetic regulatory level the genes that regulate the expression of structural genes that make a limb are *shared* by all animals. What this implies for Christology is that the hidden processes responsible for the development of our Lord's limbs are shared by other animals. What this further implies is that creatures are connected to Jesus Christ at the level of developmental evolution. God the Creator creates all things through His Son. The divine developmental communication involved in making all kinds of complex and morphologically diverse limbs of animals is fundamentally the same. And so there is a kind of singularity at the developmental genetic level and as we will see later on, this developmental expression is profoundly simple in nature. Shubin et al. 1997 called this shared genetic regulatory communication 'deep homology.' By 'deep' this shared developmental communication is 540 million years old and by ‘homology’ they are referring to a common evolutionary origin.

What is the ancient limb-forming communication responsible for the development of non-human and human limbs, including the limbs of Jesus Christ? One of the key regulatory genes involved in this communication is called Distal-less (DLL), a protein transcription factor required for limb outgrowth in all animals[25]. Transcription factors regulate the expression of structural genes directly involved in making a creature’s flesh. Transcription factors are regulatory proteins that bind to specific regions of structural genes (called the ‘cis-region’). This binding is based a physico-electric interaction of the regulatory molecule with the nucleotide sequence of the cis-region located on the structural gene. This interaction is situated just ‘above’ the quantum level, at the level where biology merges with physics. DLL was first discovered by researchers studying butterfly wing development. And so, it was butterfly wing development that eventually led biologists to better understand how the embryonic flesh of Jesus Christ developed. After antibodies to Dll were obtained, it was discovered that Dll is exclusively expressed in epidermal cells situated at the distal tips of elongated structures that will form wings. Following this discovery, it was discovered that DLL is likewise expressed in the distal cells of vertebrate embryonic limbs[26]. Amino acid sequence analysis showed that DLL is a highly conserved protein suggesting that it is highly homologous in both structure and function, just like many other developmental regulatory proteins that make animals. Knowing this, we can infer that Dll was likewise expressed in the distal-most cells of the embryonic limbs of Jesus Christ while He peacefully resided within Mary's womb. What I am inferring is that meditations on the unborn embryonic Jesus based on developmental evolution can deepen our understanding of Christ's humanity.

For our second example, we now take a glimpse at the developmental evolution of a creature's anterior-posterior (A-P) axis[27]. Once again, this example reveals a deep homology shared by creatures. The development of the A-P axis in all creatures requires the expression of Hox genes. Hox and DLL genes are members of the genetic toolkit for development. Arthropods have the following eight Hox genes: pb, Dfd, Scr, Antp, Ubx, abd-A and Abd-B. These genes regulate segmental identity along the A-P axis. The order of these genes on the chromosome corresponds to the A-P order of the segments that they regulate and is called 'co-linear' expression. For example, the genes lab, pd and Dfd are only expressed in the anterior segments that will develop into the adult head and scr, antp and ubx genes are solely expressed in thoracic segments that will produce legs and wings. The Hox family evolved by tandem duplication of an ancestral Hox gene. All Hox genes encode within itself a 180 base-pair region called the 'homeobox' that encodes a 60 amino acid protein DNA-binding domain called the 'homeodomain'. Homeodomains in all creatures are highly conserved from marine sponges to our Lord Jesus Christ.

After fly Hox genes were cloned, researchers wondered if Hox genes were required for AP axis development in other creatures. The answer is yes, all animals require Hox expression. In sponges, there are only two Hox genes, one for anterior specification and one Hox gene for posterior specification; filter-feeding lophophorates have one anterior, six middle and two posterior Hox genes; arthropods have two anterior, seven central and one posterior Hox genes; urochordates have two anterior, six central and six posterior genes and vertebrates have a four-fold duplication of Hox genes located on four different chromosomes making a total of thirty-nine Hox genes. 'Be fruitful and multiply' is the hidden theological story behind Hox gene evolution.

The deep homology of developmental processes underlies 'all flesh'. Hopefully now we can now see how deep homology at the developmental level of creaturely 'vestige' can be related to the concept of deep incarnation. God became flesh in Jesus Christ and in Christ all creatures have their being. The deep homology shared by all animals, including Jesus Christ, creates all the diverse creaturely bodies in which and through which God's presence can be experienced. In Jesus Christ, God became embodied and His body was truly vulnerable being fully human until after taken down from the cross His new resurrection body was no longer vulnerable but now glorified[28]. God suffered on the cross, being fully human, and so because of this vulnerability God hears the constant suffering of all creatures and shares in creaturely suffering.

Many theologians have recently turned to critical animal studies for insights pertaining to animals mentioned in the Bible. This 'animal turn,' as it has been called, gives non-human animals of the Bible a voice[29] and significantly sometimes the non-human voice is wiser than a human, for example see the story of Balaam's donkey.[30] In this essay, embryos are given a voice. In the Bible we read about the unborn Jesus within Mary's womb attracting the wise men and how John the Baptist leaped within Elizabeth's womb. One can imagine Jesus and John the Baptist as glorious embryos peacefully floating within their warm, ocean-like amniotic space as they embody for our future salvation. The silent vulnerability of embryos mirrors that of Jesus Christ's vulnerability on the cross. Therefore all embryos share in the stigmata of Jesus Christ. It was the experience of stigmata by St. Francis of Assisi that triggered the birth of the highly influential Franciscan tradition that flourishes today[31]. By taking the backward step through ontogenetic time, one can take the 'embryo turn' by allowing our thoughts to move backwards in time to God the Creator. Moving from the created to the Creator, from the 'vestige' to the Trinity, divine development looks both forward in time to the continuously created future and at the same time flows back in time to God the

Father, when our reflections are guided by faith in Jesus Christ, our epistemological Light. Embryos are among the most vulnerable in all creation. Fetal alcohol syndrome, mis-carriages, abortion, endless epigenetic distruptions of embryos indicate that any developmental theology must include vulnerability theology.

I am most grateful to Gregersen for his insightful papers and introducing me to the theology of St. Bonaventure.[32] Bonaventure's theology speaks to me because it is pregnant with semiotic allusions to developmental biology. How wonderful that Bonaventure's 'principle of fecundity' is central to his entire theology. This principle is presented in his 'Disputed Questions on the Mystery of the Trinity': "Supreme primacy in the supreme and highest principle demands the highest actuality, the highest fontality, and the highest fecundity. For the first principle, by virtue of the fact that it is the first, is the most perfect in producing, the most fontal in emanating, and the fecund in germinating." [33] The fecundity of all creation flows from the highest fecundity as described by Bonaventure.

Bonaventure's language of 'fecundity' and 'germinating', while used at the most subtle layer of Trinitarian knowledge, also points directly at developmental biology by way of symbolism and semiotics. Many theologians credit Bonaventure as an early forerunner of semiotics predating Charles Pierce by centuries. Semiotics, as a theory of signs, has obvious implications for religion in that what we perceive points to the transcendental[34]. Semiotic reflections on biological phenomena are called biosemiotics and there are several contemporary scholars of biosemiotics who have written about developmental biology in terms of signs. A good example of developmental semiotics can be found in a paper published by Giorgi and Bruni entitled "Germ cells are made semiotically competent during evolution." [35] This paper emphasizes the semiotic relationships between germ cells and their somatic environment as they journey towards becoming functional gametes responsible for making the next generation, a series of developmental events that make 'Be fruitful and multiply' a reality. What is emphasized is that the developmental sequence responsible for the evolution and development of germ cells 'is an open-ended semiotic relationship explored and gradually defined during evolution by the context-dependency of specific cell-to-cell interactions.'[36] Germ cell plasma membranes act as 'semiotic interfaces' [37] as the cells travel along somatic pathways from their source to their final destination, the gonad, moment by moment 'reading' molecular signs in a highly relational manner. It is these somatic-germ cell interactions that confer upon animals the ability to 'Be fruitful and multiply'. The journey of germ cells is not predetermined by developmental information solely contained within the cells, but is regulated by environmental signals ('signs'), that is, the inner developmental ecology of the creature provides creatures with the gift of fecundity.

Moving from the ‘vestige’ level of fecundity to the highest and most subtle level of fecundity, we read in Bonventure’s ‘Breviloquium’ written in 1257 where he discusses fecundity in terms of the Trinity:

> “Such a Trinity of persons does not deprive the divine essence of its supreme unity, simplicity, infinity, eternity, immutability, necessity and sovereign primacy; and yet it includes the highest fecundity, love, generosity, equality, relationship, likeness, and inseparability” [38].

David Luy has commented on this passage saying: ‘The intrinsic fecundity of the divine nature is therefore the basis and blueprint for creation.” [39] Luy continues by saying: “The finite world is a composite echo of that primal reality, which (in itself) is immense, infinite and supremely simple. It is an asymptotic exemplification of the divine fecundity. This means that the very cosmic context within which theological speech takes place is itself semiotic at its core. The fecund simplicity of God is expressed within the creaturely realm only in a language of complexity.”[40] Adding to this stream of thought, prior to the discovery of Hox genes, biologists believed that understanding of how complex animal patterns arise during development would be a daunting task, if not impossible. Yet, the answer turned out to be surprisingly simple. From the development of simple sponges to magnificent elephants, to the embodiment of God in Jesus Christ, Hox expression is required. The developmental toolkit is remarkably small and simple. Those of us thinking about this with the eye of faith know the source of this expressionism, God. God simply creates. All animal development, including the development of Jesus Christ rests upon this divine developmental communication. The embryonic creation of "all flesh" is united in a most profound simplicity at the level of Bonaventure's 'vestige.' Luy emphasizes that simplicity together with fecundity, lie at the heart of Bonaventure's theology. One can only imagine Bonaventure's excitement if alive today at the discovery of how creaturely complexity evolved from a relatively simple set of developmental regulatory genes such as Hox. Bonaventure would fully appreciate the theological implications of modern developmental biology. And so, what I am suggesting is that the study of embryos, when studied with one eye of faith and the other on modern developmental biology, has the potential to be what Bonaventure called a 'Journey of the Mind to God.'[41]

Developmental theology can be discussed in the context of deep incarnation and deep resurrection. When Gregersen presented a paper entitled "Deep incarnation: from Deep history to Postaxial Religion" to the South African Science and Religion Forum he acknowledged his profound awareness that "we are situated here amongst the birth seeds of humanity." [42] Having spent twenty years roaming wild Africa, returning to our first home is indeed a most profound experience and a most wonderful place to revel in God's creation.. From the first birth seeds planted in Africa, humans multiplied and spread throughout the earth fulfilling God's command: 'Be fruitful and multiply'. It is a most profound fact, yet often forgotten, that we are all Africans. However, the human family is now so vast that it is threatening the very existence of our planet suggests that we are now living in what is called the Anthropocene epoch in which the human population explosion coupled with our activities are contributing to climate change.[43] Therefore, 'Be fruitful and multiply' must be understood in the context of the current global climate crisis. Unlike in the past, the exponential increase in humans coupled with unbridled destructive behaviour is a major threat to our planet. It is our hope that ongoing science and theology discussions will help us discover a sustainable solution to our global crisis.

Gregersen made the following comment concerning science and theology: "The view of deep incarnation, as laid out above, cannot be translated into the worldview of empirical science, obviously. But this does not mean that there is no connection between the proposal of deep incarnation and scientific descriptions of reality." [44] What I have hopefully shown in this essay is that there is an intimate connection between modern developmental biology and theology. Connected with The empiricism of developmental biology when viewed with a mind of faith generates developmental theology, which is a profound reflection on creaturely creation guided by God's revelation in Jesus Christ. Gergersen is joined by other prominent theologians who embrace both theology and science. For example, Wentzel van Huyssteen said that "we should as theologians be able to enter the pluralist, multidisciplinary conversation with our full personal convictions intact and at the same time be empowered to step beyond the limitations of our contexts and traditions in critical self-reflection, scientists too should be empowered to embrace theology in their reflections".[45] Likewise Cole-Turner wrote: "Science should be accepted as a valid source of insight and used to advance theology's understanding of humanity. It should not be ignored." [46] Therefore, what modern developmental evolution has to say about creation, God and Christology shouldn't be ignored and what theology says about development shouldn't be ignored. Sadly, over the past four decades I have yet to meet another developmental biologist who views development 'under God.' Hopefully in the future more developmental biologists will follow the lead taken by many physicists who understand that studying the material world can bring us closer to God..

Concerning the material world and Christology, Gregersen made the following comment: "The point of Christology is that by conjoining this material world, the Father's eternal Word or Wisdom entered into the matrix of material existence as well as into the social field of human communities." [47] This 'entering into the matrix of material existence' lies at the heart of developmental theology.

Developmental theology's focus is the question of embodiment, incarnation and how Jesus Christ functions to link together all of creation in the loving embrace of God the Father, economic Trinitarianism at its finest. However we may reflect on these questions 'under God,' continuous creation in some manner or another involves God working through, by, or in developmental processes.

Developmental theology has a doxological dimension. In Ps 145 we read that 'all flesh' will bless the name of God. For an excellent theological discussion of 'all flesh' in the Hebrew Psalter read the wonderful paper by Declaisse-Walford[48]. For the development of all creaturely flesh, having now discussed the role of Hox and DLL genes, we can begin to understand the genetic basis of 'all flesh' that blesses the name of God. That is, the doxology of 'all flesh' is rooted in gene expressionism. This allows us to meditate on the question: how is it that 'all flesh' blesses God's name? 'All flesh', that is all animals, exist because of divine expressionism mediated by developmental processes that ultimately have their source in God the Father. Without Hox expression, which ultimately is God's communication of developmental information at the genetic ('vestige') level, there would be no flesh to bless God's name. The deep homology of all flesh mediated in part by Hox expression is therefore connected with the hermeneutics of doxology. The vulnerability of Jesus Christ brought to the cross all flesh in order to end the groaning and suffering of all creatures, including embryos. Therefore all flesh celebrates knowing that indeed creation and redemption are indeed one, as emphasized by Ted Peters.[49] Speaking about the deep resurrection of all creation, Elizabeth Johnson said ‘the historical incarnation goes deep into the heart of divine life, at once expressing the depths of God’s fatherly love for the world (John 3.16: ‘For God so loved the world that he gave his only son’), while also bringing into divine life the inside experience of the world of creation, so that in the end creatures will live and become united in the eternal life of God’ (John 17 22-23 ‘so that they may be one, as we are one, I in them and you in me, that they may become completely one, so that the world may know that you have sent me and have loved them them even as you have loved me.’[50] The deep homology revealed by developmental biologists is another aspect of this divine Oneness.

Despite the rapid progress in understanding developmental evolution, developmental evolution is at the same time a most profound and wonderful mystery. ‘Wonderful mystery’ is definitely not how Charles Darwin described the evolution of flowering plants. By contrast, he described the origin of flowering plants as an ‘abominable mystery.’[51] In a private letter to Joseph Hooker in 1879 Darwin wrote “The rapid development as far as we can judge of all the higher plants within recent geological times is an abominable mystery.” First of all, Darwin conflates ‘development’ with ‘evolution.’ He intuitively understood that evolution and development are intimately connected with each other. Therefore, while it can be said that Darwin anticipated the study of developmental evolution, his views on natural selection eclipsed those on development. What was 'abominable' to Darwin was the idea that flowering plants arose rapidly during the Cretaceous. This is because his theory of natural selection was solely based on gradual changes over time. The sudden appearance of higher plants was viewed as a direct threat to his theory of natural selection and pointed to a transcendental origin. No doubt that if Darwin was alive today, he would say that current saltatory theories of evolution are likewise 'abominable.'[52] From a theological viewpoint, it is abundantly evident that higher plants heard God's call to 'Be fruitful and multiply' following one of the earth's global mass extinction event and the fruit produced by higher plants has since been enjoyed by countless creatures. Despite more than a century of research, the rapid evolution of higher plants remains as much of a mystery today as in Darwin's time. Mysteries, whether in science or theology, are absolutely wonderful because they promote further research and most importantly humble us before God. When humbled, our divine creaturely relationship with God the Creator is restored and then we can truly enjoy the fruits of God's creation and revel in the beauty of Nature.

Conclusion

I have attempted to show how modern developmental biology contributes to our understanding of creation and Christology. When insights from modern developmental biology are discussed along with theological insights, what we have is ‘developmental theology’, a modern expression of economic Trinitarianism. ‘Be fruitful and multiply’ (Ps 1.28) and ‘the Word became flesh’ (Jn 1.14) are two key verses that lie at the heart of developmental theology. What developmental theology does is to further our scientific inquiry as to how and why the ‘Word made flesh.’[53] This goal can be accomplished by taking the ‘embryo turn’, that is by listening to the voice of embryos we journey closer to God our Creator. In other words, to deepen our understanding of how the Word made all flesh, we must also investigate how the Word made embryos. At this divine nexus, Logos theology meets modern developmental biology.

Notes

1. Quotations are from the NIV Bible.

2. See Ted Peters, “The eye of faith and the eye of science: Regin Prenter and Niels Henrik Gregersen on God’s creation”. *Dialog* 57: 126-132 (2018).

3. For example, as an undergraduate student back in the 1970s I was interested in the origin of chordates (Jesus Christ was born a chordate), so I spent four decades studying sea squirt development because sea squirts, not flies or mice, are phylogenetically positioned at the origin of all chordates. This being the

pre-evolutionary development era, all my professors urged me to study flies or mice proving that taking the less traveled path is often the best choice.

4. See Scott Gilbert and D. Epel, *Ecological Developmental Biology* (Sinauer Assoc Inc. Publishers, 2009).

5. See Leonard J. Bowman, “The Cosmic Exemplarism of Bonaventure” *The Journal of Religion* 55:2 (1975), 181-198.

6. See B. Myers, “The stratification of knowledge in the thought of T. F. Torrance *Scottish Journal of Theology* 61:1 (2008), 1-15.

7. Ibid., pp. 5 - 11.

8. Chapter 2 entitled ‘The Speculation on God in the Vestiges in This Sensible World’ in Bonaventure’s *The Journey of the Soul into God* begins as follows ‘With respect to the mirror of sensible things, it is possible that God might be contemplated not only through them, but also in them in as far as God is present in them by essence, power, and presence. Therefore it is a second level of contemplation by which we ought to be led to the contemplation of God in all

those creatures that enter into our mind through the bodily senses', translated by Philotheus Boehner and Zachary Hayes, (Franciscan Institute Publications, 2007), pg. 48.

9. T.F. Torrance, *The Ground and Grammar of Theology*, (T & T Clark, London, 1980), pp. 156-164 and Alister E. McGrath, *The Order of Things: Explorations in Scientific Theology*" (Blackwell Pub. 2006), DOI: 10.1002/9780470690918 pgs 97-116.

10. Scott Gilbert, *Developmental Biology* (Sinauer Associates Inc, 2013), 10th edition, 719 pages.

11. S.B. Carroll, J.K. Grenier and S.D. Weatherbee, *From DNA to Diversity Molecular Genetics and the Evolution of Animal Design* (Blackwell Publishing, 2005).

12. For an excellent summary see Fabien Revol, "The concept of continuous creation part I: History and contemporary use". *Zygon* 55, no.1 (2020) https://doi-org.ezproxy.library.ubc.ca/10.1111/zygo.12582; Joshua M. Moritz 2013. *Theology and Science* 11, no.1, (2013), 1-7 presents a valuable discussion on

'indirect' versus 'direct' creation, 'Scripture is full of examples of God "directly" creating phenomena that scientists would now consider to occur "naturally" (pg1). It could be argued that scientists investigating Nature with the 'eye of faith' understand that God creates both "directly" and "naturally,"an important topic that merits further contemplation.

13. Alister E. McGrath, "The Owl of Minerva: Reflection on the theological significance of Mary Midgley". *Heythrop Journal* LXI, (2020), pp 852-884.

14. D.M. Ornitz and N. Itoh,"Fibroblast growth factors" *Genome Biology* 2 no. 3 (2001) doi: 10.1186/gb-2001-2-3-reviews3005.

15. Lin Chen Yong-xiang LI, Chunhui Li, Yunsu Shi, Yanchun Song, Dengfeng Yu Li Zhang, "Genome-wide analysis of the pentatricopeptide repeat gene family in different maize genomes and its important role in kernel development" BMC Plant biology 18, 366 (2018) https://doi.org/10.1186/s12870-1572-2

16. From the International Agency for Research on Cancer, World Health Organization https://gco.iarc.fr

17. High cancer rates are another feature of the Anthropocene epoch. See the paper on embryonic-like cancer cell cycles by Jinsong Liu 2019 “The ‘life code’: A theory that unifies the human life cycle and the origin of human tumors”. *Semin. Cancer Biol.* (2019), 60: 380-397 doi: 10.1016/j.semcancer.2019.09.005

18. David Luy 2019 “Simplicity and Language: Bonaventure’s Semiotic Asymptoticism” *Modern Theology* 35 (2019): pg. 483. Luy quotes Ewert Cousins ‘the entire universe is God’s language’.

19. See Carroll et al. and Gilbert cited in references 10 and 11. For an excellent discussion of the spatial-temporal aspects of incarnation see T. F. Torrance, *Space, Time and Incarnation*, (T & T Clark Ltd., Edinburgh, 1997), 92 pp.

20. Suzanne Rutherford and Susan Linquist, “Hsp 90 as a capacitor for morphological evolution.” *Nature* 396, 336-342 (1998).

21. For an excellent introduction see T.E. Fretheim, *God and World in the Old Testament: A Relational theology of Creation*, (Abingdon Press, 2010), 416 pp.

22. From T.F. Torrance, *The Promise of Trinitarian Theology: Theologians in dialogue with TF Torrance* quoted by Myk Habets, in *Theology in Transposition: A Constructive Appraisal of TF Torrance,* (Augsburg Fortress Publishers, 2013), pg. 86: "Some of us are also deeply indebted to scientists who *under God* [my italics] have helped to clarify for us an understanding of the space-time world in which the Creator Word became incarnate." No doubt, T.F. Torrance would have deeply appreciated the economic Trinitarian implications of the space-time world of developing embryos revealed by *in situ* hybridization methods.

23. See Bonaventure's *Journey of the Soul into God*, see note 8.

24. Neil Shubin, Clifford Tabin and Sean Carroll, "Fossils, genes and the evolution of animal limbs" *Nature* 388: 639-648.

25. Grace Panganiban, L. Nagy and S.B. Carroll, "The role of distal-less in the development and evolution of insect limbs." *Curr Biol* 4: 671-675 (1994).

26. G. Panganiban et al., "The origin and evolution of animal appendages." *Proc Natl Acad Sci USA* 94: 5162-5166 (1997). A wonderful five page summary of the universality and simplicity of divine processes that make all appendages (wings and limbs).

27. Sean Carroll see note 10.

28. Heike Springhart, “Vulnerable Creation: Vulnerable human life between risk and tragedy” *Dialog*: a Journal of theology 56 (4): 382-390 (2017).

29. For an excellent discussion of the ‘animal turn’ in Biblical studies see Ken Stone’s *Reading the Hebrew Bible with Animal Studies*, Stanford University Press (2017), 240 pages.

30. See Numbers 22: 21-39 NIV.

31. Carolyn Muessig, “Signs of Salvation: The Evolution of Stigmatic Spirituality Before Francis of Assisi” *Church History* 82 (1), 40-68 (2013); Carolyn Muessig, *The Stigmata in Medieval and Early Modern Europe,* Oxford Scholarship online (2020) DOI: 10.1093/oso/9780198795643.001.0001. Muessig concludes her detailed analysis saying that ‘Christians did not respond with a single answer to what it meant ‘to bear the stigmata’ because the idea was a changing one that reflected different perceptions of religious life as well as distinct historical and cultural circumstances’ pg 249. My personal religio-scientific perception sees all

embryos marked with stigmata due to their vulnerability shared with our crucified Lord Jesus Christ.

32. Niels H. Gregersen, “The Emotional Christ: Bonaventure and Deep Incarnation” Dialog 55, 3: 247-261, (2016). Zachary Hayes’ writings and translations of Bonaventure’s works are essential reading.

33. Saint Bonaventure’s *Disputed Questions on the Mystery of the Trinity,* Introduction and translation by Zachary Hayes (St. Bonaventure, NY:Franscisan Institute, 2000), pg 263.

34. See Christopher M. Cullen, *The Semiotic Metaphysics of Saint Bonaventure.* Ph.D. Dissertation @ Catholic University of America, ProQuest Dissertations Publishing (2000) and Paula Jean Miller, “Cosmic Semiosis: Contuiting the Divine” *Semiotica* 178, 303-344 (2010).

35. Franco Giorgi and Luis Emilio Bruni, “Germ cells are made semiotically competent during evolution” Biosemiotics 9, 31- 49 (2016).

36. Ibid., p31.

37. Ibid., p31.

38. St. Bonaventure, *Breviloquium*, trans. Dominic Monti (St. Bonaventure, NY Franciscan Institute Publications, 2005). pg 29-30.

39. See Luy paper cited above, page 487.

40. Ibid., pg. 489.

41. See St. Bonaventure's *Journey of the Soul to God*

42. Niels Gregersen "Deep incarnation: from Deep history to Postaxial Religion" *HTS Teologiese/Theological Studies* 72 (2016) and his paper entitled "The Cross of Christ in an Evolutionary World," *Dialog: A Journal of Theology* 40(3) 192-207 (2001. http://dx.doi.org/10.111/0012-2033.00075.

43. John McKeown, *God's Babies Natalism and Bible Interpretation in Modern America* (OpenBook Publishers, Cambridge UK, 2014). http://dx.doi.org/10.11647/OBP.0048

44. Niels Gregersen, “Deep incarnation: From deep history to post-axial religion”, pg.4.

45. J.Wentzel Van Huyssteen, “Post-foundationalism and human uniqueness: A reply to responses” Toronto Journal of Theology 27:1, 73-86 (2011). http://dx.doi.org/ 10.3138/tjt.27.1.73.

46. Ron Cole-Turner, *The End of Adam and Eve: Theology and the Science of Human Origins,* (Pittsburgh:TheologyPlus Publishing, 2016) p138.

47. For a discussion of the ‘deep incarnation’ concept in its ‘zygotic’ form see Niels Gergersen, “The Cross of Christ in an Evolutionary World,” *Dialog: A Journal of Theology* 40(3): 192- 207 (2008).

48. N.L. Declaisse-Walford, “Psalm 145: All Flesh will Bless God’s Holy Name”. The Caltholic Biblical Quarterly 74, 55-66 (2012) and T.E. Fretheim, “Nature’s Praise of God in the Psalms” *Ex Auditu* 16-30.

49. Ted Peters 2015 “God and Continuing Creation,” chapter 4, pg 251- 286, in *God - The World’s Future* (Augsburg Fortress Publishers, 2015).

50. Elizabeth A. Johnson, “Jesus and the Cosmos: Soundings in Deep Christology”, in *Incarnation*, edited by Niels Gregersen (Augsburg Fortress Publishers, 2015), pages 133-156.

51. Richard J.A. Buggs, “The deepening of Darwin’s abominable mystery” *Nature Ecology and Evolution* (2017) doi: 10.1038/s41559-017-0169.

52. Saltatory or ‘jumping’ evolution is also referred to as punctuated equilibrium evolution in which creaturely phenotypic changes occur in bursts followed by long periods in which there are no changes in a creature’s form. For a recent review see Emily L. Casanova and Miriam K. Konkel, “The Developmental Gene Hypothesis for Punctuated Equilibrium: Combined Roles of Developmental Regulatory Genes and Transposable Elements”. BioEssays 42 no.2 (2020), DOI-org.ezproxy.library.ubc.ca/10.1002/bies.201900173

53. Joseph Lenow, “Christ, the Praying animal: a critical engagement with Niels Henrik Gregersen and the Christology of Deep incarnation” *International J. of Systematic Theology* 20:4 (2018), pg. 554- 578 doi:10.1111/ijst.12312.

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